Conceptual Agent-Based Model for Analyzing the Regional Impact of the Common Agricultural Policy on Structural Change in the Romanian Agriculture

Boróka-Júlia Bíró, PhD Candidate[1]
Babeș -Bolyai University
Faculty of Economics and Business Administration
Teodor Mihali Street, no. 58-60
400591 Cluj-Napoca
Romania

Abstract

Agent-based modeling is an approach receiving more and more attention within the agricultural economists' community. Incorporating the impact of individual decision making, ABMs use a bottom-up approach that studies what emerges from individual decision makings and interactions, and not a top-down - average of all – classical situation. The creation of a virtual world using ABM seems to be more realistic, but more complex, and harder to treat and to interprete its outputs. Present study proposes to give a short overview on: complex systems, agriculture as a complex system, as well as on agent-based modeling and the rationale behind using this approach in agricultural economics. In the second part of the article a conceptual model is built up that should serve as a base for studying the regional impact of different Common Agricultural Policy scenarios in Romania.

Keywords: Common Agricultural Policy, European Union, Agent-Based Modeling, impact assessment, structural change, Romania

1. Theoretical background of Agent-Based Modeling in agricultural economics

1.2. Complex systems – agriculture as a complex system

The adjective 'complex' refers to the nature of a system – that of being made up by many parts and having nonlinear connections between its elements. Nonlinear relationships result in unpredictable behaviour arising from the fact that change on one side is not proportionate with change on the other side. The aim of complex system research is to make feasible the study of the above type of unpredictable behaviour resulting from non-linearities within its parts. In comparison with linear systems - which are literally considered the sum of their parts - complex systems show a synergic character as they, as a whole are more than the sum of their parts (Lewin, 1999: 218). Though, a specific characteristic of complex systems resulting from the non-linear nature of its relationships may lead to situations when a small perturbation leads to a large effect. On the other hand, proportional effect results, or even no effect at all cases are also possible. Complex system research as a field represents the connection over the gap of individuals and the collective, from farmers to farming society and to their environment – from an agricultural economic perspective.

Complex adaptive systems are special cases of complex systems. They are complex because of their diversity and their structure based on multiple interconnection of their parts. They are adaptive because they have the capacity of learning from experience as well as the capability to change. In the case of complex adaptive systems, research studies focus on the analysis of the complex behaviour, of emergent patterns resulting from 'individual' actions and interactions, adjustments to the 'whole', adaptations to their environment. According to John Holland (1995) "a Complex Adaptive System (CAS) is a dynamic network of many agents (which may represent cells, species, individuals, firms, nations) acting in parallel, constantly acting and reacting to what the other agents are doing. The control of a CAS tends to be highly dispersed and decentralized.

[1] *Investing in people!* Ph.D. scholarship, Project co-financed by the SECTORAL OPERATIONAL PROGRAM FOR HUMAN RESOURCES DEVELOPMENT 2007 – 2013; Contract nr.: POSDRU/88/1.5/S/60185 – "INNOVATIVE DOCTORAL STUDIES IN A KNOWLEDGE BASED SOCIETY"

If there is to be any coherent behaviour in the system, it has to arise from competition and cooperation among the agents themselves. The overall behaviour of the system is the result of a huge number of decisions made every moment by many individual agents." (in Greer, 2010: 1-12.) A CAS behaves following three core principles according to Dooley (1997, in Hall and Lew, 2009: 71): order is emergent and self-organised, and not predetermined; the future behavior of the system depends on previous behavior, thus the history of the system is irreversible; and the future of the system is unpredictable. We can conclude that complex adaptive systems are composed of many individual, interacting components that show the ability of adaptation to a changing environment, can learn, self-organise and re-organise themselves.

1.2. Agent-Based Models

ABM is a relatively new method developed from the concepts and techniques of complexity theory. According to Bonabeau (2002: 7280), Agent-based modeling is a mindset more than a technology. The mindset approach meaning that the system is described from the perspective of its constituent units. Axelrod (1997: 3) defines ABM as a third way of doing science, a method in between deduction and induction. On the one hand, its starting point is like deduction's: a set of explicit assumptions, whereas its outcome does not prove theorems. On the other hand, the simulated data generated as a result of the ABM process can be analyzed inductively, also, unlike literal induction, this analysis does not base on real world data but on data from a virtual world defined previously with a set of rules and restrictions. Axelrod states in his concluding remark (1997:4) regarding the above topic the following: "Whereas the purpose of induction is to find patterns in data and that of deduction is to find consequences of assumptions, the purpose of agent-based modeling is to aid intuition", defining the purpose of ABM, that of an auxiliary method to intuition, and separating it from both induction and deduction, requiring a third way of thinking.

Agent-based models represent one type of dynamic models as an alternative of difference and differential equations, being considered an extension and generalization of cellular automata (Bernaschi and Castiglione, 2004: 35) that are suitable for modeling complex adaptive systems. While the basic characteristic of differential equations is that they describe the dynamics of a large number of interacting particles as a continuous process, resulting in an aggregate-way representation. One shortcoming of differential equations – as opposed to agent-based models – lies in this aggregation that results in the fact that the diversity of individuals, particles of a system cannot be captured. Furthermore, specificity of interactions among individuals (possible networks) as well as between individuals and their environment cannot, while spatial interactions can only poorly be represented. The above shortcomings of differential equations is – on the other hand – "solved" by agent-based models. Bonabeau (2002: 7280-7281) suggests to use ABM instead of differential equations in cases when: individual behavior shows nonlinear characteristics; individual behavior exhibits memory, path-dependence, learning and adaptation; interactions between agents are heterogeneous as well as in cases where averages do not work.

Agent-based models represent a suitable toolkit for depicting real-world complex systems by capturing complexity, containing dynamically interacting, rule-based agents. Bonabeau (2002: 7280) suggests 'microscopic modeling' as a synonym for ABM, and 'macroscopic modeling' as an alternative. Within the framework of this methodology, general assumptions regarding agents are as follows: they are supposed to be intelligent, purposeful, situated in time and space, living in neighborhood or other network patterns. Computers and specific program languages make it possible to encode in an algorithmic way the above mentioned responsive and purposeful behavior, as well as the location of agents in time and space - in a computer program. The process of modeling is one that presumes inductive approach from the modeler's side. The modeler is responsible for the actual simplification of the real-world system by applying the approximations and assumptions -considered to be most relevant to the situation, making possible to create a limited reproduction of the real system. Further, to build-up a virtual system that represents the real-one with a possible 'good fit', with agents having specific characteristics and behavioural rules (theory and reality based). And finally, to observe phenomena that emerge from the various interactions among agents, the follow micro behavior that generates macro patterns.

There is a basic contradiction regarding the research of complex adaptive systems. CASs are – by definition – unpredictable. If a system is predictable, it means it is not complex. If we build up an ABM in order to study a CAS (e.g. agriculture), we could obtain as a result of modeling what 'might happen', but we can't predict explicitly what is 'going to happen'. The contradiction lies in the fact that if we would be able to predict, that would mean the system analysed is not a complex one.

In Axelrod's view (2005: 4), agent-based modeling has core importance in interdisciplinary research, being "not only a valuable technique for exploring models that are not mathematically tractable; it is also a wonderful way to study problems that bridge disciplinary boundaries".

Properties at the system level arising from the various actions on individual level, among agents is called emergence. In Coleman's (1986) expression (in Sawyer, 2005: 76) system behavior is "an emergent consequence of the interdependent actions of the actors who make up the system". (Figure 1.).

1.3. Agent-Based Modeling in agricultural economics

Agent-based modeling is a method currently actively applied in many areas. Macal and North (2007: 99) give a sum-up of broad fields ABMs are used in, as follows: business and organizations, economics, infrastructures, crowds, society and culture, military and biology. Parker et al. (2003: 318) highlight in their study the use of multi-agent systems in the fields of: natural resource management, agricultural economics, archaeology and urban simulations. Within the economics area, agent based modeling has been developing relatively recently – nevertheless in an accentuated way - in the field of agricultural economics. In within the field of agricultural economics, agent-based modeling has recently been used to study (on theoretical and/or application level): agricultural policy impact (Berger, 2001; Happe, 2004), structural and land use change in agriculture (Balmann, 1997; Happe et al., 2006; Freeman et al., 2009; Bert et al., 2011 and Parker et al., 2003, Valbuena et al., 2008; Valbuena et al. 2010), computational modeling in agricultural economics (Torii et al., 2006; Macmillan and Huang, 2007; Nolan et al., 2009). We do not intend to provide a complete review of all possible studies here from the area of agricultural economics in relation to ABM, above references being however highlighted as considered both recent and relevant in the field.

2. Designing an Agent-Based Model for studying the regional impact of different Common Agricultural Policy scenarios in Romania

2.1. Purpose of the model

The purpose of the model would be to analyze ex-ante the impact of the change of the Common Agricultural Policy (focusing on both Direct Payments measure of CAP 1st Pillar and national subsidies, as well as on Rural Development subsidies of the 2nd Pillar*)* on structural change – physical and economic size dynamics - in Romania, on NUTS3 (county) level. The central research question is how farm structures - physical and economic size change in response to particular policy switches in within the CAP? How they are possibly going to change due to different policy scenarios after 2013 (ex-ante analysis)?

2.2. Hypotheses

In line with the above stated purpose of the model, and according to Romanian agricultural specificities, the following possible research questions arose that could be tested:

- Do direct payments and/or rural development supports lead to land concentration?
- Is there a chance - enabled by agricultural policy settings - for the small Romanian farms to convert into more efficient middle-sized family farms?
- Will there be 'space to grow' for the middle-sized agriculture in Romania?
- Can small farms survive if they cooperate?
- Is there a chance for mentality switch in the terms of: are individual farmers willing to lease out their land (motivated by agricultural policy) and accept the fact that they are only 'land owners' and not 'agricultural producers'?
- Do CAP supports slow down or accelerate the Romanian structural change process?
- The impact of different support schemes on the distribution of farm household income – is the current polarized situation going to change?

A rather complex structure is needed to make the model capable to test all of the above stated hypotheses. As a starting point a simpler model should be built up to test some of the basic ideas, afterwards being further developed to capture all the aspects. The set of hypotheses should be further refined – when actually programming the model – in terms that can be quantitatively tested.

2.3. Initialization

Model initialization is going to be based on empirical data. The model is going to represent a Romanian NUTS 3 level region – e.g. Covasna county - a predominately rural region (according to both OECD definition and new urban-rural typology) of Romania - as an agent-based system. The agricultural structure of any Romanian NUTS3 level region (e.g. Covasna county) is going to be virtually represented by defining a set of typical farms characteristic to the region, and then 'multiplying' them using certain weights in order to realistically represent the region:

- share of farms in different size classes
- share of plant producing farms (in diff. size classes)
- share of animal breeding farms (in diff. size classes)
- average farm size
- age distribution of holders
- share of IF (SF & SSF & FF) and CF

For the Base Period, the model is going to be calibrated to the empirical data of the study region. A set of individual farm data is needed that matches regional characteristics. Spatial distribution of sample farms that represent the study region are not going to be explicitly modeled spatially, i.e. their location and neighborhood relationships will be random when we initialize. This approach can be supported by the idea of simplification when modeling, the useless and almost impossibility of elaboration of a 'one-by-one scale map', as well as by the idea of upscaling (after we defined certain typical farms, we multiply each type based on the empirical distribution observed in the region, so that the shares stay the same). Neighborhood relationships are going to 'form' once we randomly fill the space by randomly locating the farms specified (that are typical), in the shares observed they appear in the region.

2.4. Scenarios

As the model proposes to test the impact of possible future policy changes, it should implement different future CAP scenarios. Some possible future policy scenarios for ex-ante analysis (some based on legal proposals presented on 12th October 2011 (Table 1.) – most recent planning metadata regarding the CAP post 2013, some related to Romanian governance, others hypothetical – considered relevant to be tested from a Romanian agricultural perspective. Some of them refer to first pillar's market measures, while others to rural development measures of the second pillar):

- Continuation of phasing-in process of Direct Payments in Romania using Single Area Payment Scheme (i.e. continuation of current policy), until reaching 100% of EU DP in 2016:

2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
25%	30%	35%	40%	50%	60%	70%	80%	90%	100%

- Simplified system for small farms: small farms only should apply for Direct Payments only at the beginning of the programming period (7 years/ 5 years (if programming period changes)) and receive it during the whole period, yearly + less verification procedures (=> less administrative costs of the policy)
- Introduction of taxes – by the Romanian Ministry of Agriculture – on fallow lands (type: penalty tax. Justification, rationale: to facilitate land consolidation and to remove weeds from the fields which highly affects the harvesting process on neighbouring parcels)
- Reduction of sale/lease transaction costs in Romania
- Introducing an EU-wide flat-rate (significantly reduced payments)
- Fix direct subsidies (lump-sum payments) for small farms (amounts between 500 and 1000 euro)
- Capping direct payments at 300.000 euro
- Gradual abolishment of Direct Payments
- Instant (prompt) abolishment of Direct Payments
- Certain amounts (concrete numbers) of per hectare Direct Payments levels (Single Area Payment Scheme + Complementary National Direct Payments) as possible future scenarios to be tested

- The introduction of new agri-environmental measures via EAFRD
- The introduction of insurance measures for farmers to protect them against price volatility
- Applying double budget for agricultural research
- Special support of organisations of agricultural producers ()
- Special support for young farmers

A central question – to be answered - would be whether the Common Agricultural Policy contributed to the amplification or mitigation of the concentration of the Romanian farms.

2.5. Submodels

The following submodels (for the whole overview of the process and scheduling see Figure 2) shall be built in:

policy settings: setting initial/changed policy environment (e.g. phasing-in Direct Payments is going to be firstly introduced as currently ongoing 'political framework').

farmers' options: types of activities farmers can opt for: sell/buy/rent land, cooperate, stop/continue farming. Farmers' sets of options are going to be pre-defined.

farmers' decisions: The behaviour of farmers should be modeled with a Cobb-Douglas function, i.e. we presume that farmers make their production decisions in a given policy environment, at a given point of time following the form of a Cobb-Douglas function. The basic process should be that each farmer tries to execute the behaviour which implies the highest income for him, given the purchase price (cost) of each factor and the selling price of the output, and also the level of subsidies available in the current programming period. Farmers are making decisions based on certain probabilities derived from observed data - decision making matrices, ranking different alternatives. So, farmers make their decision using a Cobb-Douglas function for household income maximization, knowing the prices of input factors and the price of output they are going to produce, the amount of subsidies, etc. (for the conceptual map of household income maximization see Figure 3). The probabilities to sell/buy/rent land, willingness to cooperate, likelihood to stop/continue are also intended to be considered within the framework of present model.

farmers' interaction: regarding only those activities where bilateral agreement is needed (sell/buy, rent, cooperation). During this procedure farmers inform each other about their own willingness to sell/buy/rent land or cooperate, and the action takes place if a bilateral agreement is reached. Information change and interaction takes place only among farmers within a certain distance (as farmers are not interested in 'far' located plots) .
actions: farmers take action;

- in cases, where no additional plots are desired to be involved into production/ sold (according to the result of the previous, household income maximizing process), though only unilateral decision-making is needed, action takes place after taking decision
- where interaction is needed – because of reaching bilateral agreement on selling/buying/renting plots and cooperating - action only takes place if a bilateral agreement is reached (as a result of decision making and interacting processes). If – for example – a farm intends to buy 1 ha of land in the 'neighbourhood' and there isn't a farm – within the preference distance - which would like to sell 1 ha of land, the farm which wanted to buy land produces what he initially wanted/ or what he had produced before but on a smaller scale he would have wanted: the land he currently owns/rents (as there wasn't an opportunity for him to involve more land into production)/ exits farming. Or: if no bilateral agreement is reached, than no action is taken and the farmer who intended to buy a certain amount of land goes back to his decision making process and repeats it with the restriction that he knows there wouldn't be any free plots for him to get in the neighbourhood.

update farms: updates each farms' dataset after 'actions' procedure and due to time pass (e.g. update farmers' age).

update landscape: updates landscape after farm data has been updated.
The relationship between above presented submodels is depicted on Figure 4.

2.6. Emergence

The agriculture sector of an economy being considered as a complex adaptive system, exhibits emergent properties, i.e. properties at the system level arising from the interactions of agents at the individual level.
Emergence – within the framework of present model's design – should be understood as the enlargement/shrinkage of farms, that covers the research question we intend to analyse: whether there is a possibility for structural change to take place in the region, i.e. what kind of patterns of average farm size occure presuming different policy scenarios (as external factors), with a given internal structure and characteristics of farms in the region analysed. We propose to study, how individual farmer's decisions – based on both farm internal (farmsize, holders' age) and farm external driving factors (landscape, policy) - affect regional structural change. What impact of agricultural political surroundings (external factor) and farm internal factors (aging, successorship) have on farmers' decisions and how do these individual decisions affect structural change in the region? How does individual decisions of farmers affect structural change?

3. Conclusion

The conceptual model presented within the framework of this article shows high level of complexity when it comes to the development of the actual computer program on the one hand, and the more complex the model the more demanding the validation process – on the other hand. Difficulties can also occur regarding (Leombruni and Richiardi, 2005): the interpretation of the results of simulation dynamics as well as the generalisation of them; estimation of the simulation model; validation of the model; comparing simulated distributions with real world observations.

Having the theoretical background and the conceptual model, the third phase would be its implementation. A suitable environment for 'putting it in practice' could be NetLogo[2]. After implementation, verification (both theoretical and computational) and validation (comparing with previous work and/or real world observations, deductive reasoning) procedures are going to be also needed in the view of complete finalization of modeling.

Acknowledgements

The author would like to thank Prof. Dr. Alfons Balmann for his valuable comments and suggestions during the process of theoretical and methodological design of the conceptual model.

References

Axelrod (1997): *The Complexity of Cooperation. Agent-Based Models of Competition and Collaboration*, Princeton Studies in Complexity, Princeton University Press, pp. 247

Axelrod, R. (2005): Agent-Based modeling as a bridge between disciplines, North-Holland, pp. 21.

Balmann, A. (1997): Farm-based Modelling of Regional Structural Change: A Cellular Automata Approach. *European Review of Agricultural Economics* 24 (1): 85-108.

Berger, T. (2001): Agent-based spatial models applied to agriculture: a simulation tool for technology diffusion, resource use changes and policy analysis, *Agricultural Economics,* Volume 25., Issue 2., pp. 245-260.

Bernaschi, M. and Castiglione, F. (2005): Computational features of agent-based models, *International Journal of Computational Methods,* Vol. 2., No. 1., pp. 33-48
citeseerx.ist.psu.edu, 10.1.1.107.7593.pdf, accessed on: 26.10.2011

Bert, F. E., Podestá, G. P., Rovere, S. L., Menéndez, Á. N., North, M., Tatara, E. Laciana, C. E., Weber, E., Toranzo, F. R. (2011): An agent based model to simulate structural and land use changes in agricultural systems of the argentine pampas, *Ecological Modeling,* Volume 222., Issue 19., pp. 3486 - 3499.

Bonabeau, E. (2002): Agent-based modeling: Methods and techniques for simulating human systems', *Proceedings of the National Academy of Sciences of the United States of America,* Vol. 99 (SUPPL. 3), 7280--7287.

Dooley, K. (1996): A Nominal Definition of Complex Adaptive Systems, *The Chaos Network*, 8(1): 1-3. http://www.public.asu.edu/~kdooley/papers/casdef.PDF, accessed on 28.10.2011

Freeman, T., Nolan, J. and Schoney, R. (2009): An Agent-Based Simulation Model of Structural Change in Canadian Prairie Agriculture 1960-2000, *Canadian Journal of Agricultural Economics*, Volume 57., Issue 4., pp. 537-554.

[2] http://ccl.northwestern.edu/netlogo/, accessed on 10.02.2012

Greer, K. (2010): *Thinking Networks – The Large and Small of it: Autonomic and Reasoning Processes for Information Networks* http://books.google.com/books?id=jy05ogfxpLgC&printsec=frontcover#v=onepage&q&f=false accessed on: 25.10.2011

Hall, G.C. and Lew, A. A. (2009): *Understanding and Managing Tourism Impacts. An Integrated Approach*, Contemporary Geographies of Leisure, Tourism and Mobility, Routledge, 365 pp. http://books.google.ro/books?id=BUEFydelbJQC&printsec=frontcover&hl=ro#v=onepage&q&f=false , accessed on 28.10.2011

Happe, K. (2004): Agricultural policies and farm structures - Agent-based modeling and application to EU-policy reform. Studies on the Agricultural and Food Sector in Central and Eastern Europe, Vol. 30, Halle (Saale). http://www.iamo.de/dok/sr_vol30.pdf accessed on: 05.04.2011

Happe, K.; Kellermann, K.; Balmann, A. (2006): Agent-based Analysis of Agricultural Policies: An Illustration of the Agricultural Policy Simulator AgriPoliS, its adaptation and behaviour. *Ecology and Society* 11 (1): 49.

Leombruni, R. and Richiardi, M. (2005): Why are economists skeptical about agent-based simulations?, *Physica A: Statistical Mechanics and its Applications, Volume 355., Issue 1., pp. 103-109.*

Lewin, R. (1999): *Complexity: Life at the Edge of Chaos*, second edition (first edition in 1992), The University of Chicago Press
http://books.google.com/books?id=77xDnidtPS8C&printsec=frontcover#v=onepage&q&f=false accessed on: 27.10.2011

Macal, C. and North, M. (2007): Agent-based modeling and simulation: Desktop ABMS, in *'Proceedings - Winter Simulation Conference'*, pp. 95 - 106.

Macmillan, W. and Huang, H. Q. (2008): An agent-based simulation model of a primitive agricultural society, *Geoforum*, Volume 39., Issue 2., pp 643-658.

Nolan, J., D. Parker, G., van Kooten, C., Berger, T. (2009): An Overview of Computational Modeling in Agricultural and Resource Economics. *Canadian Journal of Agricultural Economics/Revue canadienne d'agroeconomie,* 57**,** 417-429.

Parker, D.; Manson, S.; Janssen, M.; Hoffmann, M. and Deadman, P. (2003): Multi-agent systems for the simulation of land-use and land-cover change: A review', *Annals of the Association of American Geographers* 93(2), 314-337.

Sawyer, R. K. (2005): *Social Emergence. Societies As Complex Systems,* Cambridge University Press http://books.google.ro/books?id=Hgs007Rd_moC&printsec=frontcover#v=onepage&q&f=false accessed on: 26.10.2011

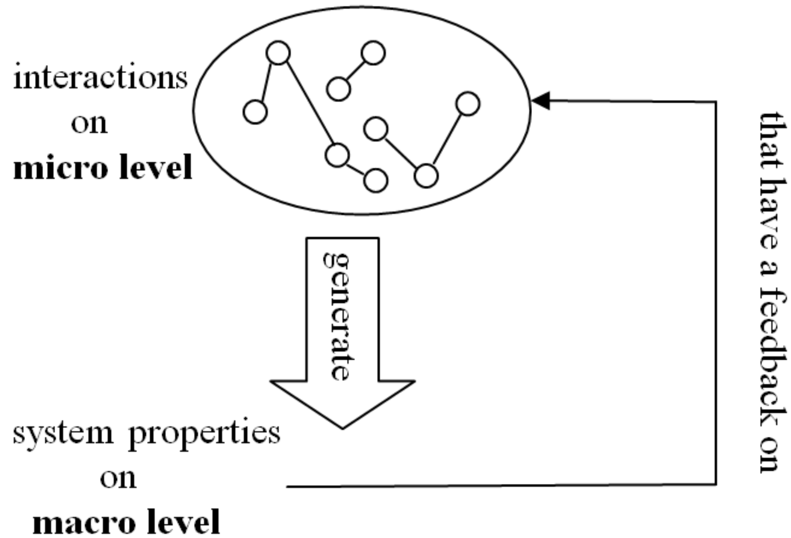
Torii, D., Ishida, T. & Bousquet, F. (2006): Modeling agents and interactions in agricultural economics, *in* 'AAMAS '06: Proceedings of the fifth international joint conference on Autonomous agents and multiagent systems', ACM, New York, NY, USA, pp. 81-88.

Valbuena, D., Verburg, P.H., Bregt, A. K. (2008): A method to define a typology for agent-based analysis in regional land-use research, *Agriculture, Ecosystems and Environment,* Volume 128., Issue 1., pp. 27 – 36.

Valbuena, D., Verburg, P.H., Bregt, A. K., Ligtenberg, A. (2010): An agent-based approach to model land-use change at a regional scale, *Landscape Ecology*, Volume 25., Issue 2., pp. 185-199.

APPENDIX

Figure 1: The phenomenon of emergence



Source: own edition

Table 1: New directions of the European Union's Common Agricultural Policy

1.	Fix direct subsidies (lump-sum payments) for small farms (amounts between 500 and 1000 euro)
2.	Capping direct payments at 300.000 euro
3.	Payments per hectare related to the adoption of ecologic practices
4.	New agri-environmental measures via EAFRD
5.	Insurance measures for farmers to protect them against price volatility
6.	Double budget for agricultural research
7.	The support of organisations of agricultural producers
8.	The support of young farmers
9.	Stimulating employment in rural areas
10.	Higher attention regarding LFAs

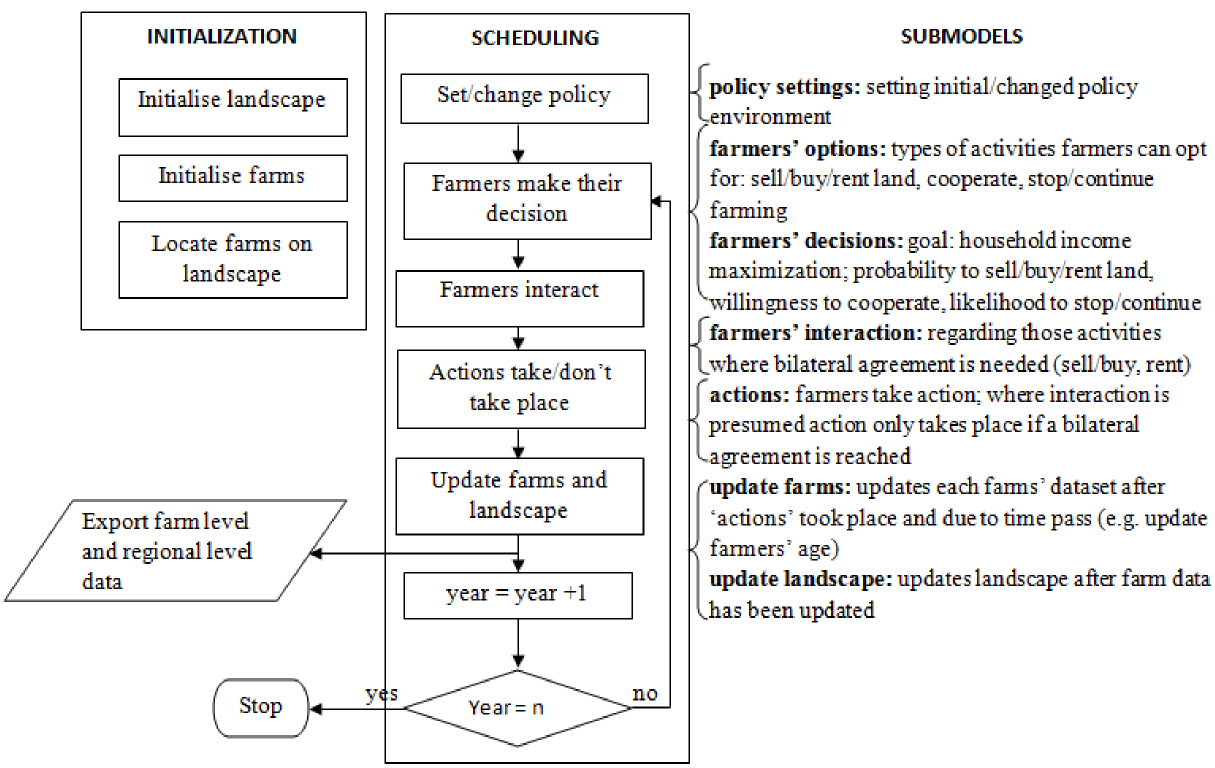
Source: summary based on legal proposals from 12.oct.2011
http://ec.europa.eu/agriculture/cap-post-2013/legal-proposals/index_en.htm , accessed on 15.01.2012

Table 2: Entities, state variables and scales

Entities	State variables	Scales
Farm agents	- **amount of land they are operating on** (owned and rented, in ha) - **type of farming** (Individual: SF, SSF, Family farms or Corporate farms) - **factor endowment** (buildings, machinery) - **finance** - **age** (years) - **level of education** (primary/secondary/higher) - **availability of successor** (yes/no) - **location of household** (x, y coord. Or the grid cell it occupies, list of neighbours)	***Spatial resolution of the model:*** Spatial units explicitly modeled by grid cells, (e.g. 0.25 ha each) **Temporal resolution of the model:** 1 year time steps
Landscape	- **plots** (each grid cell means 1 plot of 0.25ha) - **type of land** (arable land, pastures & meadows)	
Environment	- **policy setting** (selected measure(s) of current CAP, i.e. Direct Payments from first pillar, specific Rural Development measures from the second pillar, national subsidies)	

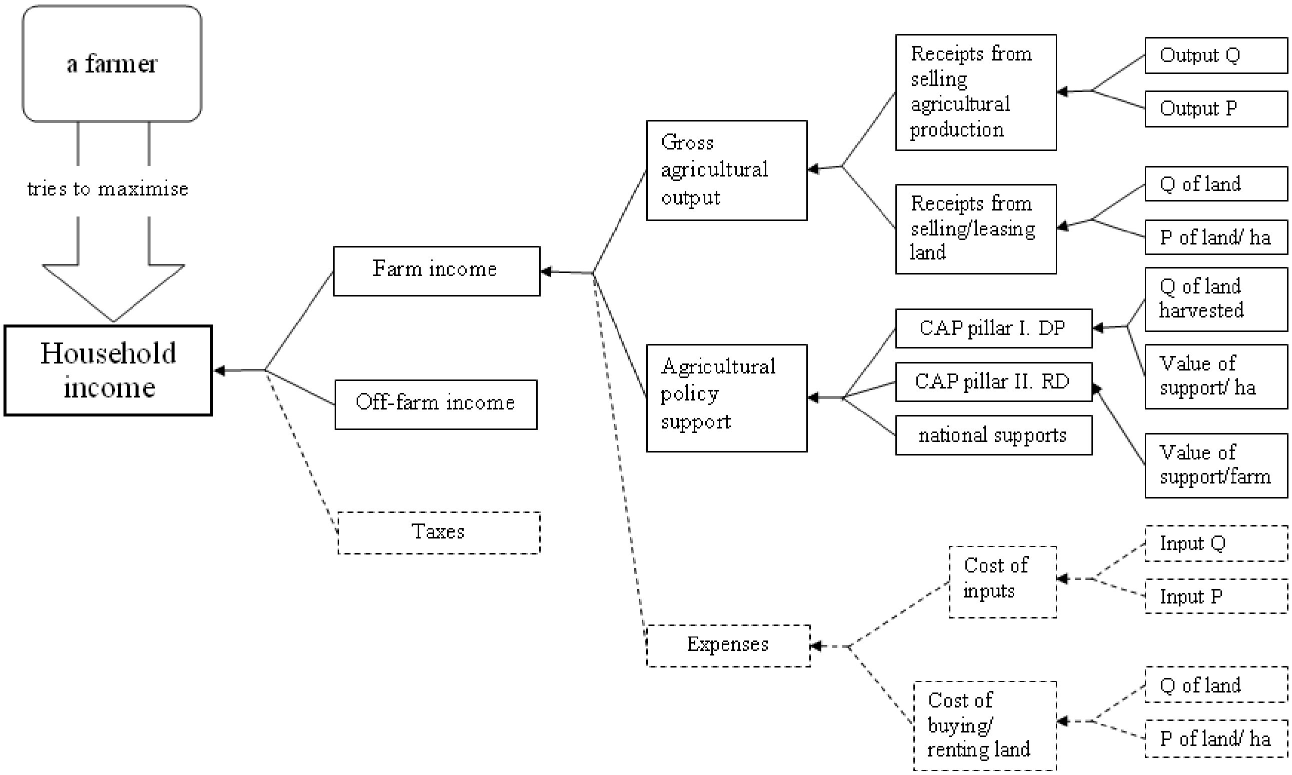
Source: own edition

Figure 2: Process overview and scheduling



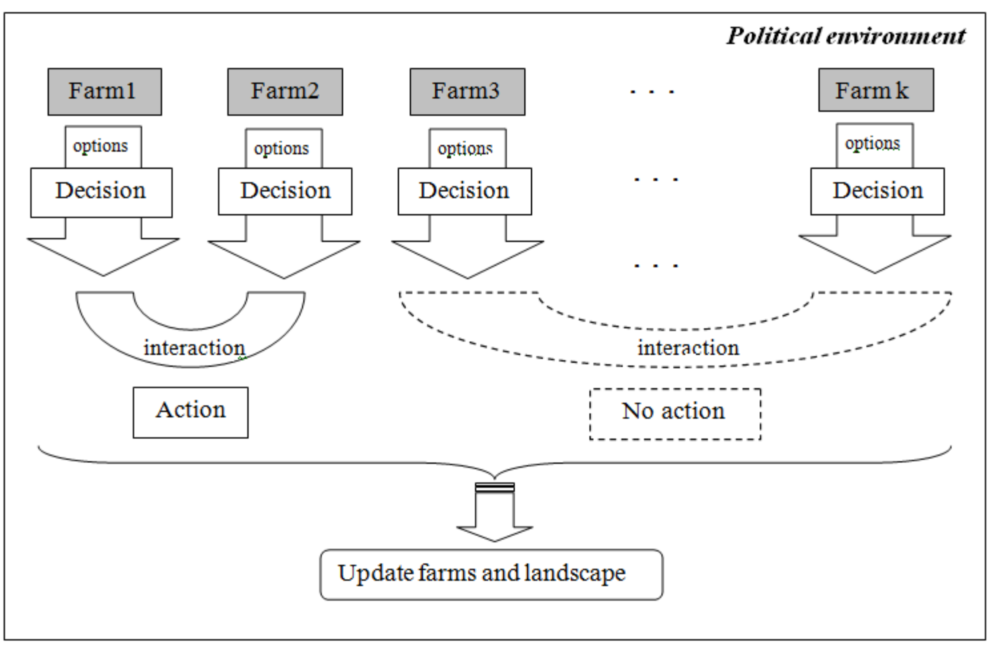
Source: own edition

Figure 3: Conceptual map of household income maximization



Source: own edition

Figure 4: Relationship between the submodels



Note: interaction takes place among farmers within a certain distance*

Source: own edition